Individualized Instruction and the Computer: Potential for Mass Education[1]

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A recent technological innovation, computer-aided instruction, may soon be a major vehicle for offering individualized learning to large segments of our population. Simultaneously, the computer can analyze and adapt teaching sequences to the learning abilities of each person, thus insuring true compatibility of individual and education. Because there is an inescapable demand for the student to respond actively to the instructional device, this innovation can provide a much broader learning experience than other mass communications instructional media—such as television, motion pictures, and radio—which elicit more passive behaviors. Marshall McLuhan (15) has captured wide attention with his suggestion that our electronic-age media provide far different learning events than those that occur when we read a book. Certainly, computer-aided teaching will further increase the magnitude of these electronic media experiences and establish a unique domain of its own.

Currently, prototype models of computer-based teaching terminals offer instruction via cathode-ray tubes, teletypewriters,

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motion picture, slide, and television display screens, and through headsets connected to tape recorder units. These terminals are being used in pure and applied research settings, on university campuses, or in school districts where they are providing instruction to learners at various age levels. In most instances, the teaching terminals are in close proximity to the computer. Some know-how has been obtained, however, in transmitting instruction via telephone lines from a computer to a campus located many miles away. The challenge that confronts our modern technology is the development and validation of a computer and terminal system that will enable many teaching terminals situated at remote locations, 50 to 100 or more miles from the computer, to provide instructional sequences in many content areas, at low per unit cost, with high operating reliability, and at the same time utilize modern media.

This paper examines some aspects of the student-teaching terminal relationship followed by a consideration of potential networks for mass education. Concerns for research are also outlined.

UNIQUE CHARACTERISTICS

One can justifiably ask a basic question: What are the special characteristics of this instructional medium that can further mass education? The traits of self-pacing, interaction, presentation of instructional sequences based on prior responses and available past information, diagnosis of weaknesses in skills and abilities that are often overlooked by human evaluation, and the ability to employ different media for basic and remedial sequences are primary examples. Assuming that some students or some subjects may be more effectively taught by one or a variety of media indicates that computer-aided instruction has considerable untapped potential. In describing terminals that utilize a number of media, Suppes (19) points out that ". . . There is already a good deal of evidence that students at all grade levels come to feel as much at home with the sort of terminal I have described as they do with an ordinary television set."

How does the computer's selective ability operate in adapting instruction to each student's needs? This may be accomplished by displaying sequences of varying difficulty, providing remedial sequences when diagnosis based on responses indicate the need, altering sequences and presentation modes, transferring control of the machine to the learner, and giving the learner opportunities to respond in many different ways. Data obtained about the stu-

dent, prior to his using the terminal, may also be indirectly incorporated into the sequence—such factors as vocabulary skill level, mathematical aptitude, reading comprehension levels, etc.

Certain subtle but meaningful dimensions are evident when using these terminals, especially the interaction between student and machine. An individual gains a sense of "molding" his instruction much the same as a potter molds clay. The presentation is responsive to his replies, and he can see a set emerging which is modified by his input. The "hands-on quality" of typing and/or using a light pen also gives him feedback through the tactile senses. These experiences may fulfill a need for contemporary man to be a "craftsman," or at least actively participate in the highly personal process of learning. As Hannah Arendt (1) suggested in her *Human Condition,* a gratification comparable to the craftsman of ancient times is needed today. Perhaps in this interaction, the individual is creating his instructional "work of art" from start to finish as did the craftsmen of old with their products. The person sitting at the terminal is involved in the process of creating *his* instructional "urn."

Many computer-aided instruction programs have been written to provide drill and practice sequences as well as to provide tutorial programs. In some respects, these teaching sequences approximate traditional linear or branching programed instruction provided in teaching machines of varying shapes, sizes, and complexities. However, the computer-aided teaching sequence is not static but is in a constant state of evolution and dynamic growth. Rapid updating of sequences can be accomplished concurrently with use based upon (a) analysis of student responses made while at the terminal, (b) student attitudes expressed following instruction, and (c) identification of new content to insert into the program, thus providing new related dimensions to student backgrounds and current academic needs. As Wing (21) suggests, "... the individualization would be effective only when there was a combination of learning circumstances which would be appropriate to the diagnosed characteristics of the individual learner." Such a *gestalt* can be offered to the learner when computer-aided instruction is at its best; it is at this point that this medium can facilitate a learning experience singular in its own right.

Another special dimension of the computer-aided instrument that has vast potential is the ability to use the storage and retrieval capabilities of the computer as a problem-solving tool. An

individual can simulate or play actual problem-oriented "games" which enable him to make real-life decisions about various complicated situations. These are based on the alternative relationships that the computer can describe. The "game playing" can serve one student's educational needs or it can offer alternatives for decision making to those in business or government. A detailed description of variations in computer-aided programs is provided by Stolurow and Davis (18) and Zinn (22). All of the foregoing characteristics of this medium, if creatively programed, could provide moderate amounts of unpredictable change and "arouse" the individual. As Berlyne (2) suggests, "arousal" involves a heightening of attention that helps individuals to act and to learn.

VALID EDUCATIONAL OBJECTIVES

Recognizing the flexibility of this teaching system, what are some of the principal applications that we might devise? Shall we continue to utilize such an innovation merely to teach facts? Could we profitably examine the taxonomies of educational objectives more closely and discover certain learning behaviors that can particularly benefit from the inherent capabilities of computer-aided instruction?

Within the cognitive domain, as organized by Bloom and others (3), the categories of comprehension, analysis, synthesis, and evaluation might be incorporated into the simulation and gaming sequences and problem-solving sequences mentioned above that employ the computer's extensive storage and retrieval capabilities. Other possible uses include teaching segments that require tasks such as interpretation, extrapolation, analysis of relationships and organizational principles, derivation of sets of abstract relations and judgments based on terms of internal evidence and external criteria.

Why should we dwell on teaching knowledge of specifics with this innovation? Why require a supersonic teaching device to fly at low altitudes (other than for "take-offs" and "landings") while consuming large quantities of "fuel," and thereby ignore its maximum performance capabilities?

If we accept the assumption that this system can provide unique "experiences," then we must also examine the affective domain. Intertwined with the cognitive domain, its five categories, as identified by Krathwohl and others (13), are also relevant to this discussion. The authors of this taxonomy argue that it is difficult to distinguish where one domain leaves off and the other begins

in any learning experience. However, computer-aided instruction may also enable a student, while dealing with complex cognitive tasks, to gain satisfaction from responding and to develop a greater commitment to learning since contingencies for learning are so arranged that feelings of failure while at the terminal are minimized. Attitude change and increased motivation for learning could occur. Such a commitment may well carry over into *other* areas of instruction and help the student to reorganize total value systems and feelings of personal worth, thereby possibly altering his academic and vocational pursuits.

Any consideration of computer-aided instruction, therefore, must take into account its ability to deal with a range of learning objectives, a range greater than those encompassed by any self-instructional device yet created. Such a technique can, at the same time, incorporate the attributes of the instructional mass media as well as benefits derived from access to a sizeable data bank.

THE IMPERSONAL ASPECT

The impersonal nature of the man-machine relationship is relevant to any discussion of computer-aided instruction. Undoubtedly, many people will compare the capabilities of the computer-based teaching terminal with those of the classroom teacher. Those involved in computer-aided instruction would agree that an attractive, smiling, receptive teacher may indeed be able to impart more knowledge. However, any comparison study probably would show results that would indicate no significant differences between the two teaching sources when the teacher, using the same visual devices available at the terminal, follows identical teaching sequences. An ineffective teaching sequence, whether presented by a teacher or a terminal, is a poor sequence. A summary of 112 comparison studies of self-instructional materials with "traditional instruction," accompanied by criteria, was provided recently by Gilbert (10).

The capability of providing impersonal, individual instructional diagnosis via the terminal cannot be underestimated. Many students, whether they be adolescents or adults, are reluctant to expose their lack of knowledge to other people. They may, if they do not understand, ask to have a statement repeated twice, but seldom thrice. These students are handicapped too by the possibility that the teacher will not be providing an alternate statement based on some perception of what the individual does not

understand, but merely a verbatim repeat of the original statement. Even if the individual student should patiently request the same information ten times, unquestionably the speaker would have departed or refused further verbalization; not so the computer. The computer-based terminal has infinite patience; it can repeat if requested and may permit a person to take as long as he wishes before responding to any inquiry.

For pupils at all age levels who have experienced difficulties operating in the traditional academic milieu, the teaching terminal may provide the contingencies of reinforcement and the learning set which would enable the person to enter the mainstream of educational activity.

In another respect, the impersonal nature of the device may lend itself as efficiently to what numerous authors have called our "alienated society" (11). This situation is not as negative as it may sound, however, for to learn without involvement with another human being, to have no commitment or obligation to share his psychological space, may be appealing to many. Jacques Ellul (7) would probably observe that these terminals are just another predictable aspect of our technological society, a society which has for its major goals the attainment of measurable objectives, standardization of procedures, and efficient results.

THE IMMEDIACY OF NEEDS

Individual student needs, or wider educational objectives such as mass retraining involving the development of skills, can be handled at the teaching terminal. Skills can be improved through interaction with "real-life" problem-solving situations, problems which can be increased in complexity as the individual improves. Uttal (20) provided a fine example of how this might be done in teaching steno-typing skills.

Another area of application that is a current concern involves teaching culturally deprived youngsters. This may well be met in part by computer-assisted instruction. Remedial sequences provided by an audio component, or the best combination of media devices based on response pattern, might overcome any lack in ability to handle verbal stimuli due to cultural deprivation and also provide a bridge to more effective use of verbal tools. Explorations in this area have been made by this author (9).

Another remote transmission of instruction that has possibilities for future nationwide use might be one supplying answers to housewives' questions on problems relating to budget manage-

ment and the selection of dinner menus, etc. It is not unlikely that a terminal per household, one in each office or classroom, will be as accepted as is the television or radio today.

POSSIBLE NETWORK CONFIGURATIONS

For educational use tomorrow, a central computer operating on a time-sharing basis could simultaneously provide instruction at 200 to 300 teaching terminals located hundreds of miles from the computer center. Such a system is already within the state of the art, and Harvey Long (14) has demonstrated its efficacy on a small scale using a number of separate locations. Pennsylvania State University also has experimented with a related transmission problem in work in computer-assisted instruction (16). The feasibility of linking computers at three campuses, and thus permitting student access to instruction at all three, is being investigated by the University of Michigan, Michigan State University, and Wayne State University (12).

Some educational sharing of computer resources, whether the terminals are placed at individual locations or in clusters, will evolve as an important adjunct to present college curricula. The challenge to higher education institutions to integrate computer-assisted instruction potentialities into their established programs has yet to be accepted or even realized by many universities. A recent effort by EDUCOM (6) provided a major forum to consider such problems.

Perhaps separate organizations will evolve devoted to providing educational programs to meet not only the requirements of colleges and universities but also the needs of every sector of our society. The catalogue of sequences meanwhile will grow and provide a wide assortment of offerings and an excellent intellectual bill of fare. In contrast to the rapid yet somewhat haphazard growth of the program textbook and teaching machine field, the computer-assisted instruction area is striving to insure adequate software for the hardware components and proceeding with calculated caution due partially to the intricate nature of this operating complex.

IN-SERVICE TEACHER EDUCATION

As one approach to providing individualized instruction to 5,000 people located in different sections of one state, the State Education Department of New York and System Development Corporation are currently implementing the first phase of a study designed to investigate the feasibility of a statewide computer-based instructional network for in-service teacher education, under the direction of the author. Teaching terminals would be located at

school sites and available for use at the teacher's convenience. The network would transmit teaching sequences developed by master teachers, sequences that also might be utilized in their classrooms. The terminals, initially, would be used to teach biology content while employing display units, teletype, audio units, and film cartridge capabilities. Remote transmission of content would give the teacher the opportunity to engage with computer technology prior to her students, and hopefully motivate her to partake of other available established courses for in-service education.

Considerable effort is also being expended by many groups in the installation of computers in school districts to meet educational data processing needs. These units, if of sufficient size and flexibility, may be utilized for instructional as well as administrative purposes.

With these computers in place, content developed for the remote terminal network by master teachers could be made available to local computer centers. Computer programs, compatible with local equipment, could be transported to many locales for use by schools, community self-study centers, or universities. One advantage of a center for the development of instructional sequences is an opportunity for elementary, secondary, university, and adult education personnel to participate and interact during content-development activities. Successful patterns for such endeavors have been established by BSCS (Biological Sciences Curriculum Study), PSSC (Physical Sciences Study Committee), and SMSG (School Mathematics Study Group).

Regardless of how computer-aided instruction is integrated into our present patterns of teaching, it *should not* be regarded as a threat to the teacher or as an agent displacing either traditional or modern methods of teaching. Rather, it should be looked upon potentially as a tireless friend who may help increase individualized instruction and aid us in learning more about how and why we learn.

SOME CONCERNS FOR RESEARCH

If the technological innovation of computer-aided instruction is to have any impact on the problem of mass education, some feasibility studies will have to be conducted to determine if terminals made available in remote operational locations will be used, and with what results. Psychological, sociological, and economic factors also must be considered in any assessment of its value. Since this instructional system consists of a number of complex com-

ponents, concerns of researchers and product developers should include:

1. The evolution of better teaching strategies needed to fully set to work the capabilities of the computer as a problem-solving device, and also to employ the simulation and data storage attributes. Instructional computer programs that can handle these requirements also must be developed.
2. The design of programs that can record student responses and then present them for analysis in a rapid and intelligible fashion, thereby providing data on how a wide range of individuals might respond under "fixed" conditions of instruction. Such information would clearly suggest where revision might be made to improve the instruction.
3. An assessment of patterns of learning behavior before and after terminal use.
4. An evaluation of the physical components of teaching terminals and how they aid or detract from the effective use of terminals at remote locations.
5. A determination of low-cost effective multimedia teaching terminals which will be reliable at remote settings.
6. An integration of instructional programing languages now in use must be explored. Effort to develop unique capabilities in each language is commendable. However, a common language could combine in an acceptable fashion many of the characteristics of the three to four *principal* languages currently being used, thus permitting instructional sequences to be exchanged on a large scale. The problems related to computer-machine languages are acknowledged. Nonetheless, any delay in implementing an effort in this area permits the problem to be compounded at a very high interest rate.

As indicated by Silverman (17), the stage has been set for a major breakthrough in instructional technology due to the mergers of a number of electronic and textbook firms. Formerly, in statements by Coulson and others (5), related suggestions were made to researchers operating in laboratory settings. A few were heeded and applied. Now with firms who are conditioned to dealing with problems of mass distribution and mass consumption entering the field, the climate is ripe for a significant application of computer-aided instruction to the problems of mass education.

Developments in hardware, including monolithic-printed cir-

cuits, application of plasma physics to low-cost visual display components (8), as contrasted to expensive cathode-ray tube production, microwave relay systems, plus exploration of phonophone use as a visual display unit, all indicate some major advances toward developing low-cost systems and terminals. Time sharing should bring even lower computer use cost. With a considerable investment in time and effort, the software problems can be surmounted. Television developments and wide-scale adoption provide an analogous utilization pattern for mass education.

Regardless of the user population, this type of instruction, although computer based, is *student* centered. The question to be answered is: "Are we willing to invest our psychological and technological know-how to provide such individualized mass education?"

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